JPL

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34TH AIAA THERMOPHYSICS CONFERENCE
TRENDS AND ISSUES IN THERMAL SPACECRAFT MANAGEMENT PANEL DISCUSSION

Use of Passive Versus Active Systems

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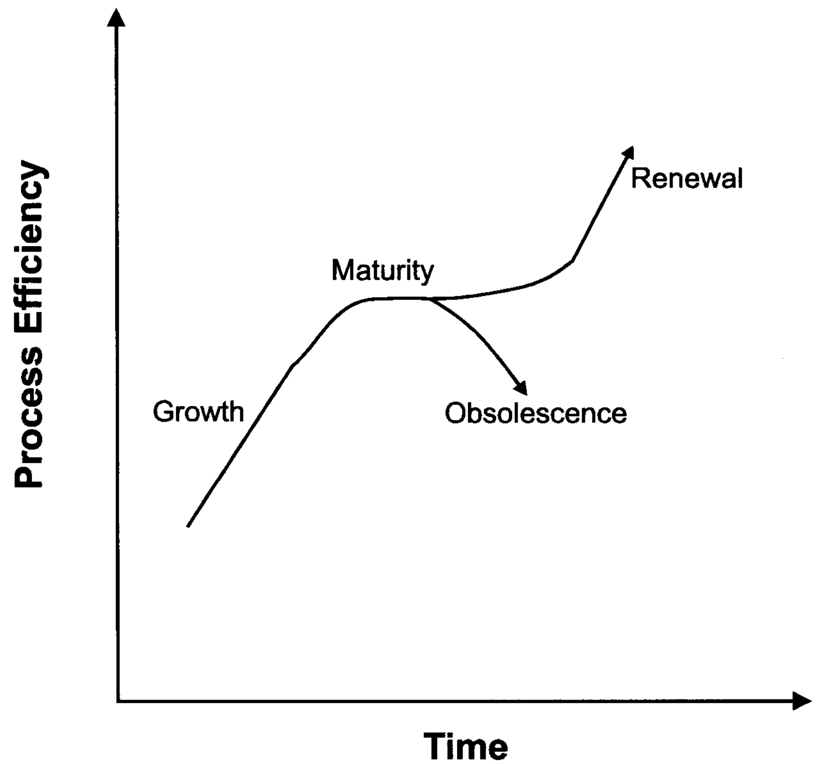
Agenda

- A Word About Processes: "It worked on Apollo and I don't see why it shouldn't work now!"
- Thermal Analyst Versus Thermal Engineer
- A Word About Recent Design Challenges: "You're going where and with how much power!!??"
- Mission-Enabling Thermal Designs
  - Passive & Active Approaches
- Overview of Enabling Thermal Control Approaches
- Conclusions

A Word About Processes: "It worked on Apollo and I don't see why it shouldn't work now!"

- All processes have finite life cycles
- Standard passive spacecraft system thermal design approaches have been employed for nearly 40 years
- Take on a competitive mindset to renew the thermal design process



Thermal Analyst Versus Thermal Engineer

- Avoid the "lobbing over the fence" process => thermal design in a reactive mode since it is last in the serial chain
  - Problems uncovered too late in development cycle
  - "Band-aid" resolutions implemented
- Spacecraft thermal design is a systems job => help drive the mechanical configuration

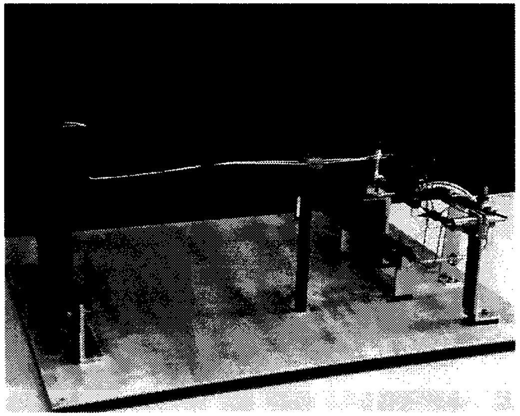
A Word About Recent Design Challenges: "You're going where with how much power!!??"

- Interplanetary Thermal Environment
  - 10 solar constants at Mercury
  - 0.1 solar constant at Pluto
  - Earth environment Is a subset of a larger picture
- Design Space Variance
  - Microspacecraft to large inflatable structures
  - Power-starved (<100 W) to high power dissipation (>10 KW)
  - High power density electronics
  - Ultra-stable optical benches (< 10 mK/hr)

Mission Enabling Designs

- **PASSIVE**
  - Phase change thermal energy storage for planetary surface diurnal thermal control Mars surface Missions
  - Light weight high performance thermal insulation for Mars missions
  - Mechanical thermal switch
- **ACTIVE**
  - Loop heat pipe systems (including by-pass valve) for survival heater power reduction for earth orbiting and deep space missions
  - Mechanical pumped fluid system: Mars Pathfinder Heat Rejection System
  - Variable emissivity surfaces

Miniature Loop Heat Pipe Technology



• Miniature loop heat pipe (Dynatherm Corporation)

Technical Description

- A versatile thermal control device: transfers heat, controls source temperature, and acts as a heat switch (all in one)
- Light weight (less than 150 gms) device compared to other thermal control hardware performing the same function
- Enormous flexibility in locating heat sources and sinks on the spacecraft

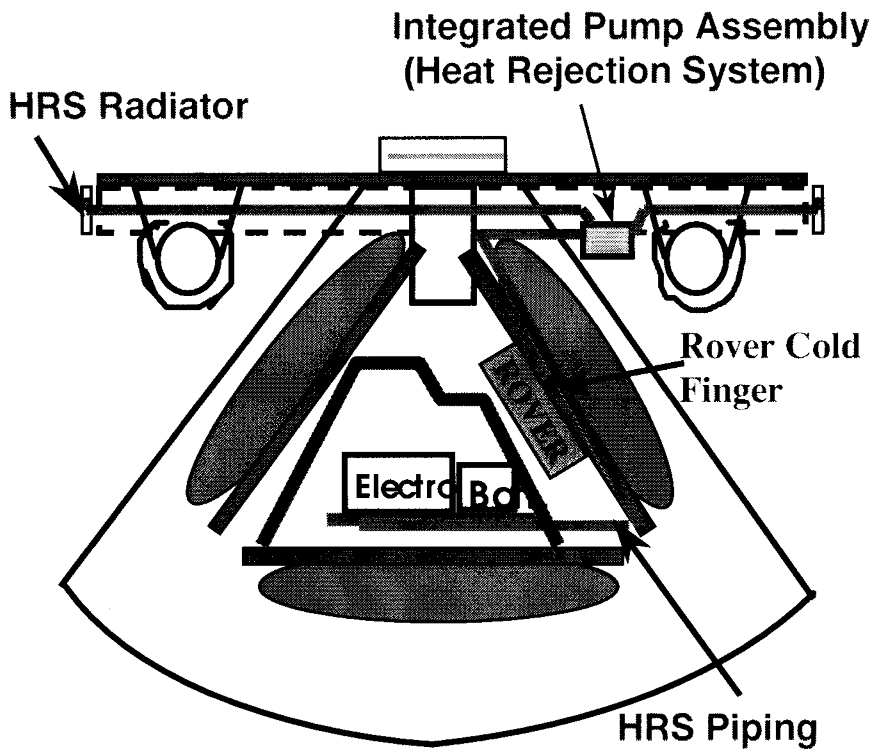
Participants & Facilities

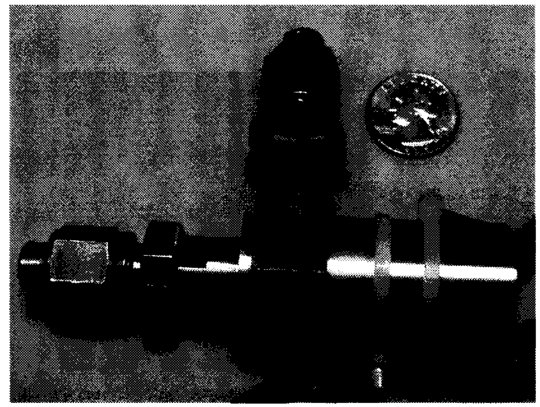
- JPL is investigating this technology for space applications (Mars rover/lander, micro S/C)
- Tests to be performed at JPL and Goddard during FY00 for evaluating miniature multiple evaporator loop heat pipe
- Dynatherm Corporation has designed and fabricated a miniature loop heat pipe for Mars Rover battery thermal control concept

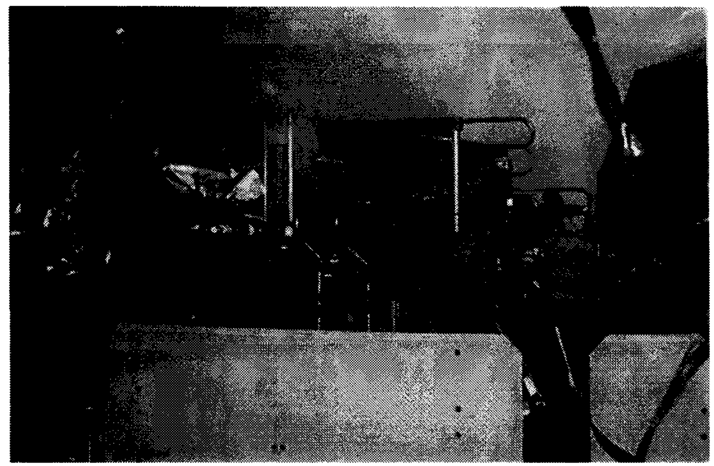
Mission Impact & Future Applications

- This technology reduces S/C thermal control mass and provides enormous flexibility
- This is a key technology for enabling Integrated Thermal Energy Management System for DSST 2nd Delivery
- This technology is applicable to small & large S/C and planetary vehicles thermal control

Mars Pathfinder Mechanically Pumped Cooling Loop

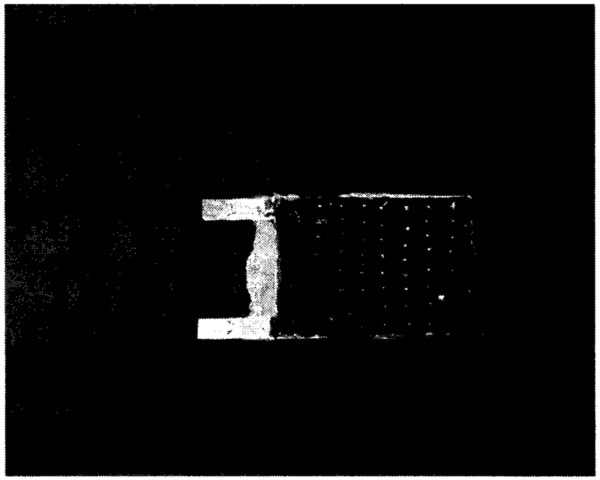






- Electronic equipment shelf maintained within +/- 2 C for entire cruise

Variable Emissivity Surfaces (Electrochromic)



Electrochromic device from Ashwin-Ushas

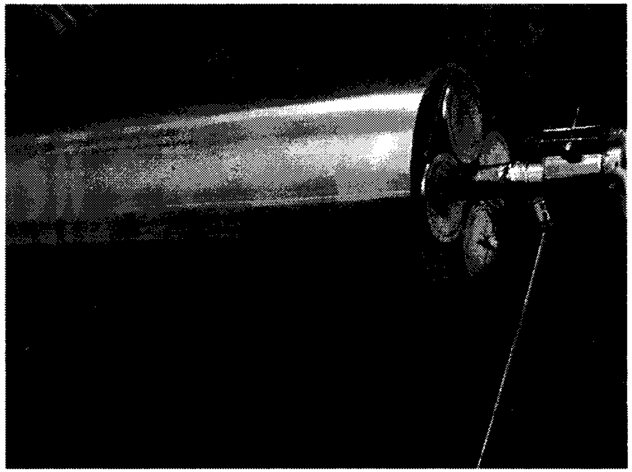
Description

- A change of surface emissivity in the range of 0.3 to 0.8 by an external electric field of < 5V
- Provides a low mass (0.5 kg/m^2) device to vary heat rejection capacity on the spacecraft (order of magnitude lighter than mechanical louvers)
- Conducting polymer material used as electrochromic material
- Devices based on similar materials used for auto and building energy conservation

Status & Future Applications

- Significant work by EIC labs, LBL Berkeley, ASHWIN-USHAS, NASA Lewis
- JPL, GSFC & AFRL investigating for S/C use
- Excellent candidate for JPL's Integrated Thermal Energy Management (ITEM) systems for future spacecraft
- Initial validations tests: 10 Mrad Gamma radiation
- Space qualification of the material is an important next step;
  - Thermal vac and radiation tests at JPL
  - Solar wind tests at GSFC
- Device failure mechanisms in space applications need to be understood

Phase Change Thermal Storage for Battery Applications



Description:

- Phase change material (PCM) utilizes latent heat to protect batteries against low temp. extremes by providing thermal storage
- PCM stores excess heat when available and releases the heat when needed
- The technology is simple, reliable, and mass efficient

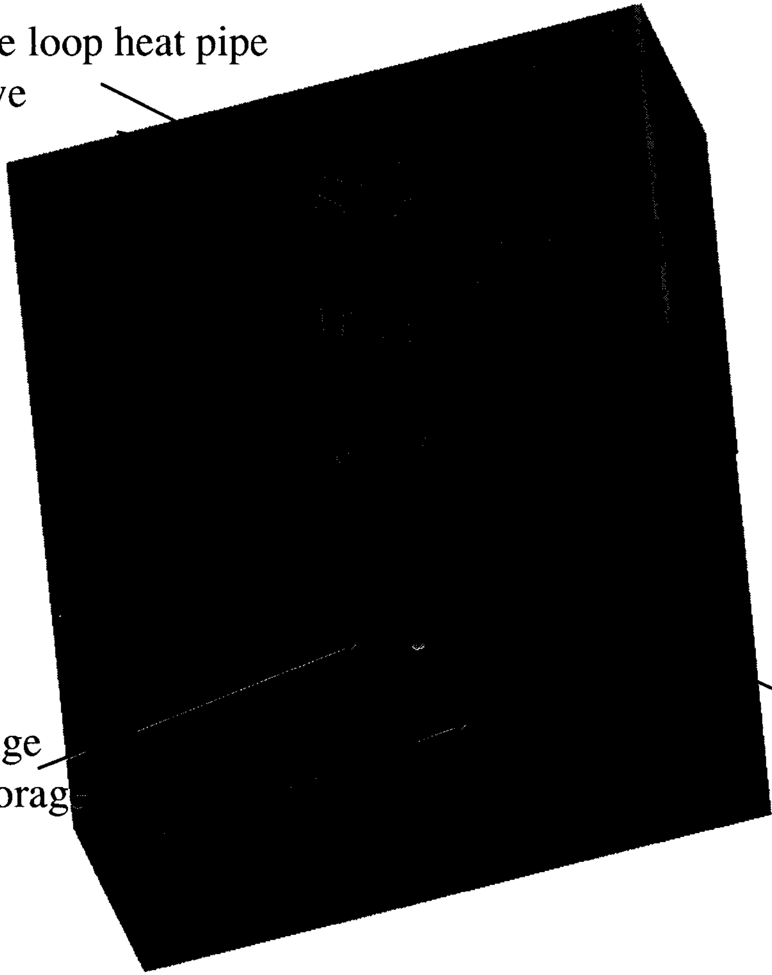
Current Status:

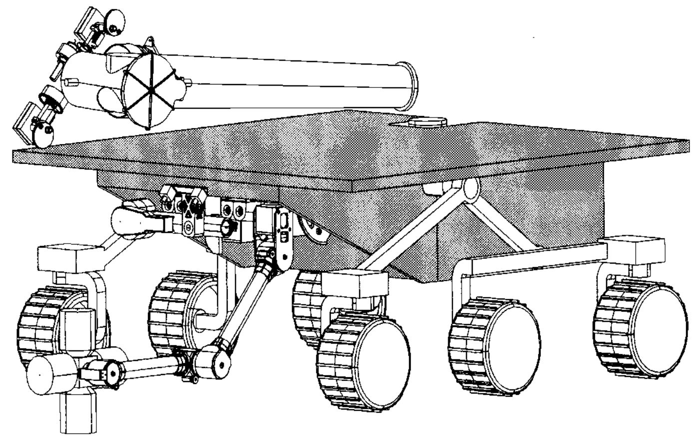
- Dodecane PCM material (-10 C MP) encapsulated in a carbon fiber matrix
- A battery/PCM capsule was fabricated by ESLI for JPL
- It is integrated with miniature LHP and being tested at JPL in a simulated Martian environment to evaluate rover battery/electronics thermal control

Future Development:

- Investigate PCM materials with lower MP for lower temperature operations (below -20 C)
- Develop and qualify low mass system for thermal energy management on Mars landers, in-situ experiments and Microspacecraft missions

Mars Rover Thermal Control Design





Initial testing at JPL completed in April 2000

Conclusions

- A shift in the thermal design process is essential to keep pace with demanding spacecraft capability
  - Leverage emerging thermal hardware to develop straightforward and robust designs
- Take a proactive role in the conceptual development stage to strengthen use of emerging thermal approaches